AlliedWare Plus™ OS

How To | Configure Hardware Filters on SwitchBlade x908, x900-12XT/S, and x900-24 Series Switches

Introduction

The SwitchBlade x908, x900-12XT/S, and x900-24 series switches support a powerful hardware based packet-filtering facility.

These switches can filter on a range of Layer 2, Layer 3, and Layer 4 packet attributes, and perform a variety of different actions on the packets that match the filters.

Because the filters are hardware-based, they put no load on the CPU of the switch, and do not affect the throughput of the switch. It is possible to configure over 1000 different filters, and still have complete wire speed throughput on the switch.

On the AlliedWare Plus OS, hardware-based packet filtering is carried out by using *hardware ACLs* (Access Control Lists). The following configuration methods are available:

1. To make a simple filter based on IP address, MAC address, TCP/UDP port, or ICMP type, you simply create one or more ACLs and apply them to a port.

   You can build up a filter hierarchy by applying multiple ACLs to a port (e.g. make one ACL to allow traffic from a source IP address to a destination address, then a second ACL to drop all (other) traffic from that source IP address).

   This How To Note calls ACLs that are applied to ports **interface ACLs**.

2. To make a filter based on a range of other packet settings, you use QoS match commands in one or more QoS class-maps, mostly in combination with ACLs. Then you use QoS to apply the class-maps to a policy-map and port.

This note describes both approaches. Then it gives a series of examples, and ends by discussing how many filters you can make.

Contents

Which products and software version does this Note apply to?

- Products: SwitchBlade x908, x900-12XT/S, and x900-24 series switches
- Software versions: 5.2.1-0.1 and above

Hardware filters are also available on Layer 3 switches running the AlliedWare OS. For AlliedWare OS configurations, see the AlliedWare OS How To Notes:

- *How To Use the Hardware Filters on the AT-8948 and AT-9900 Series Switches*
- *How To Configure Filtering Actions on QoS Flow Groups and Traffic Classes*

These Notes are available from www.alliedtelesis.com/resources/literature/howto.aspx.

Creating hardware ACLs

Hardware ACLs contain both the match criteria and the action to take on matching traffic. There are two types of hardware ACL: IP address and MAC address. These are indexed by their ID number. IP hardware ACLs have a number in the range 3000 to 3699 and MAC hardware ACLs have a number in the range 4000 to 4699.

The following table shows the available ACL ranges as displayed by the ? help, and highlights the hardware ACLs.

Number range	Description
1-99	IP standard access list
100-199	IP extended access list
1300-1999	IP standard access list (expanded range)
2000-2699	IP extended access list (expanded range)
3000-3699	**Hardware IP access list**
4000-4699	**Hardware MAC access list**
extended	Named IP extended access list
standard	Named IP standard access list

The ACLs give you the following choice of actions to take on matching traffic (see "The effects of the action keywords in ACLs" on page 6 for details).

Action parameter	Description
copy-to-cpu	Specify packets to copy to the CPU
copy-to-mirror	Specify packets to copy to the mirror port
deny	Specify packets to reject
permit	Specify packets to permit
send-to-cpu	Specify packets to send to the CPU

Creating IP hardware ACLs

IP hardware ACLs filter packets from the following IP protocols:

- IP
- ICMP
- TCP
- UDP

This section describes how to create ACLs to filter packets from each of these protocols.

IP packets

You can filter IP packets on the basis of their source and/or destination IP addresses. The command syntax is:

```
awplus(config)#access-list <3000-3699> <action> ip <source-ip-address>
   <destination-ip-address>
```

The source and destination IP addresses can be any of the following:

- a subnet. To specify this, enter the address and mask. You can specify the mask in slash notation or with a wildcard (reverse) mask:

```
awplus(config)#access-list 3000 permit ip 192.168.0.0/16 ...
awplus(config)#access-list 3000 permit ip 192.168.0.0 0.0.255.255 ...
```

- a single host. To specify this, enter the keyword **host** and then the address:

```
awplus(config)#access-list 3000 permit ip host 192.168.0.1 ...
```

- all source IPs or all destination IPs. To specify this, enter the keyword **any**:

```
awplus(config)#access-list 3000 permit ip any ...
```

ICMP packets

You can filter ICMP messages on the basis of:

- source IP address and/or destination IP address (using the same syntax as when filtering IP packets)
- ICMP message type, by specifying a type number. Popular types to filter include Echo Reply (0), Echo Request (8), Redirect (5), Destination Unreachable (3), Traceroute (30), and Time Exceeded (11)

The command syntax is:

```
awplus(config)#access-list <3000-3699> <action> icmp
   <source-ip-address> <destination-ip-address> [icmp-type <value>]
```

For example, the following ACL matches on all ICMP messages from 192.168.0.0/16:

```
awplus(config)#access-list 3000 permit icmp 192.168.0.0/16 any
```

For example, the following ACL matches on ICMP redirect messages to and from any address:

```
awplus(config)#access-list 3000 permit icmp any any icmp-type 5
```

TCP and UDP packets

You can filter TCP and UDP packets on the basis of:

- source IP address and/or destination IP address (using the same syntax as when filtering IP packets)
- source and/or destination TCP/UDP ports.

The command syntax is:

```
awplus(config)#access-list <3000-3699> <action> {tcp|udp}
   <source-ip-address>
   [{eq|gt|lt|ne|range} <source-port> [<source-port>]]
   <destination-ip-address>
   [{eq|gt|lt|ne|range} <dest-port> [<dest-port>]]
```

To determine which ports to filter, use the following keywords:

Keyword	Selects	Example
no keyword	All ports	For example, to match packets that use any TCP source or destination port: access-list 3000 permit tcp any any
eq	A single port	Specify a single port number. For example, to match packets from any IP address that use TCP source port 5100: access-list 3000 permit tcp any **eq 5100** any Note that the TCP port parameter is optional. In this example, the keyword **any** indicates that the ACL matches on any source and destination IP address. The absence of a port at the end of the command indicates that it matches on any destination port.
gt	All ports higher than the specified port number	Specify a single port number. For example, to match packets that use a source TCP port of 5100 or higher: access-list 3000 permit tcp any **gt 5099** any
lt	All ports lower than the specified port number	Specify a single port number. For example, to match packets that use a source TCP port of 5100 or lower: access-list 3000 permit tcp any **lt 5101** any
ne	All ports except the specified port	Specify a single port number. For example, to match packets that use any source TCP port except port 5100: access-list 3000 permit tcp any **ne 5100** any
range	A contiguous range of ports	Specify the lowest and highest numbers in the range, separated by a space. For example, to match packets that use TCP source ports 5100 to 5200 inclusive: access-list 3000 permit tcp any **range 5100 5200** any

Creating MAC address hardware ACLs

MAC address hardware ACLs filter packets on the basis of their source or destination MAC address.

The command syntax is:

```
awplus(config)#access-list <4000-4699> <action> <source-mac-address>
   <destination-mac-address>
```

The source and destination MAC addresses can be any of the following:

- a range of MAC addresses. To specify this, enter a MAC address and the mask. Specify the mask as a wildcard mask:

  ```
  awplus(config)#access-list 4000 permit 1234.1234.1234 0000.0000.000f
     ...
  ```

  (this example selects MAC addresses from 1234.1234.1230 to 1234.1234.123f)

- a single MAC address. To specify this, enter the MAC address and a mask of 0000.0000.0000:

  ```
  awplus(config)#access-list 4000 permit 1234.1234.1234 0000.0000.0000
     ...
  ```

- all MAC addresses. To specify this, enter the keyword **any**:

  ```
  awplus(config)#access-list 4000 permit any ...
  ```

The effects of the action keywords in ACLs

Let us consider the effect of each the possible action keywords.

Action	What it does	When do you need this action?
deny	Drops the traffic.	Use this when the filtering policy is to disallow certain traffic flows.
permit	Forwards the traffic normally.	Use this when you want to: • discard a wide range of traffic, but still forward some small subset of traffic within that range. • use the ACL in a QoS class-map to select traffic for the switch to apply QoS settings to (like queue shaping).
copy-to-cpu	Forwards the traffic normally, and also sends a copy of each packet to the CPU.	Use this when you want software monitoring of a certain packet flow. If you want to log, or count, or output debug pertaining to a certain stream, then create an ACL that matches the packets in the stream, and specify the copy-to-cpu action.
send-to-cpu	Drops the traffic, but also sends a copy of each packet to the CPU.	Use this when you want software monitoring of a certain packet flow that is being dropped. If you want to log, count, or output debug pertaining to a certain disallowed stream, then create an ACL that matches the packets in the stream, and specify the send-to-cpu action.
copy-to-mirror	Forwards the traffic normally, and also sends a copy of each packet to the mirror port.	Use this when you want to mirror only a certain stream, instead of mirroring all traffic on a port.

Making filters by applying hardware ACLs to ports

You can create a filter by simply applying one or more ACLs to a port, as long as you can select the matching traffic through hardware ACL keywords, as described above.

ACLs can be applied to switch ports and static channel groups. To apply an ACL to a dynamic (LACP) channel group, apply the ACL to all ports that can be in the channel group.

The hardware filters act on incoming traffic, so apply them to the ingress ports.

Attaching ACLs

To apply ACLs to ports, enter interface mode for the port or ports you want to attach the ACL to, and then use one of the following commands:

For IP hardware ACLs:

```
ip access-group <ip-acl-number>
```

For MAC hardware ACLs:

```
mac access-group <mac-acl-number>
```

If you have multiple ACLs on a port, attach them to the port in the order in which you want the switch to check them—see "The logic of the operation of the hardware filters" on page 13. You can alternate IP and MAC ACLs, like in the following example:

```
awplus(config-if)#ip access-group 3200
awplus(config-if)#ip access-group 3100
awplus(config-if)#mac access-group 4300
awplus(config-if)#ip access-group 3150
awplus(config-if)#mac access-group 4350
```

Viewing port information

To see a list of the ACLs that are directly attached to a port, use the following command:

```
awplus#show interface <range> access-group
```

Changing ACL order

It is not possible to change the order of ACLs once you have attached them to a port. Instead, remove ACLs from the port by entering interface mode for the port and using the commands:

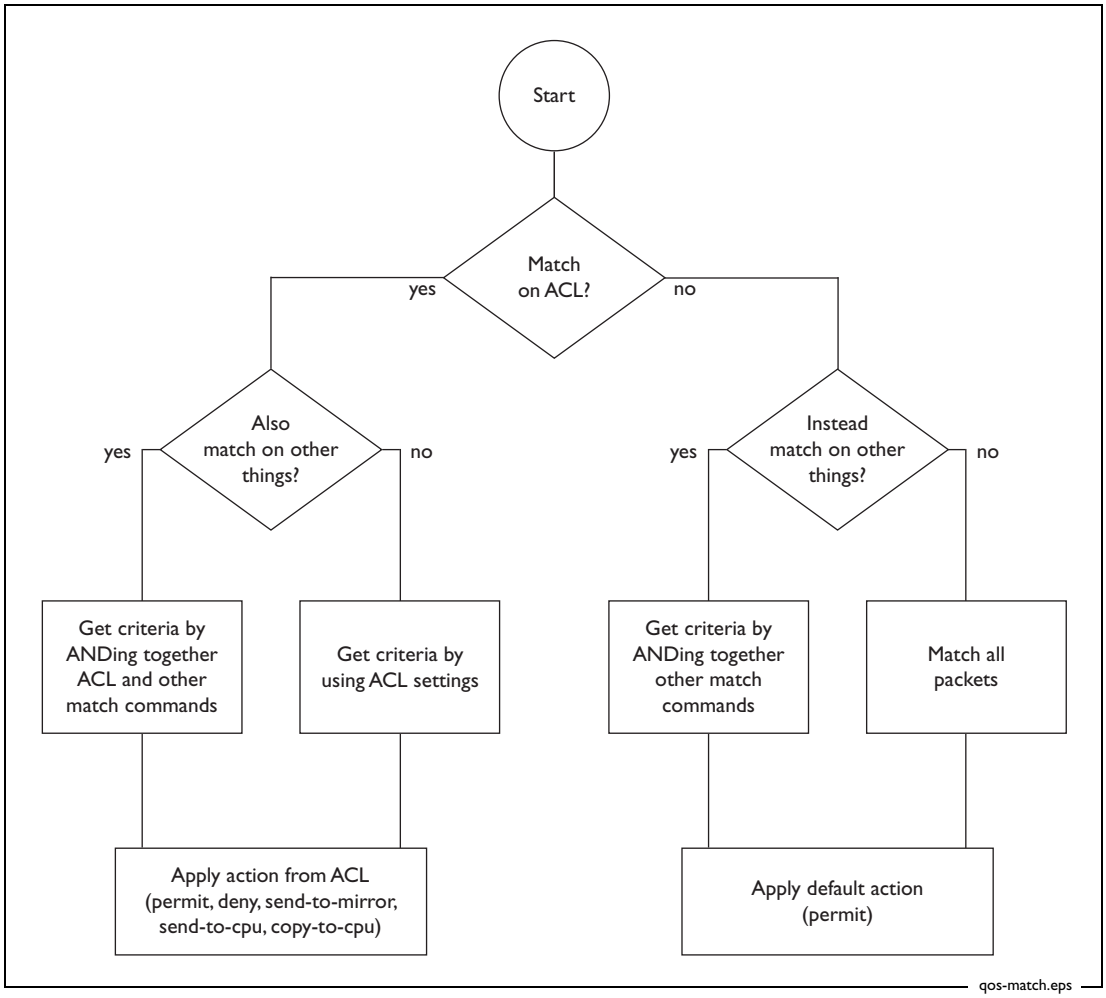
```
no ip access-group <ip-acl-number>
no mac access-group <mac-acl-number>
```

Then re-enter them in the desired order.

Making filters by using QoS class-maps

QoS class-maps allow you to match on a much wider range of packet attributes than ACLs by themselves. They do this by determining the match criteria from an ACL, or from match commands, or from both in combination. Also, they use an ACL to decide what action to take on a packet, unless you want the default action of permit.

The following figure summarises the class-map logic flow. Note that a class-map with no match commands (including no ACL match) matches on all traffic and forwards it. You could use such a class-map to apply QoS policing to a port, but would not be likely to use it when filtering.



Therefore, the basic procedure for using a class-map as a filter is:

1. Make an ACL to match on MAC address or IP settings, and to specify the action that QoS will take on traffic that matches the class-map.

   You need an ACL to specify the action—unless the action is permit—even if you don't want to match on MAC address or IP settings. In that case, make an ACL with the desired action and with both source and destination address of **any**. For example, if you want to deny traffic from one VLAN ID, you need an ACL with action of **deny** and addresses of **any**.

2. Create the class-map (see page 9).

3. Specify what the class-map will match on (see page 9). This involves:
   - attaching the ACL to the class-map
   - using other match commands to further limit what the traffic will match the class-map (unless the ACL's settings were enough)
4. Attach the class-maps to a policy-map (see page 12).
5. Attach the policy-map to the ingress port or ports (see page 12).

The following sections describe how to do each of these steps (except creating ACLs—that's described from page 3).

Creating a class-map

To create a class-map, enter global configuration mode and use the command:

```
awplus(config)#class-map <name>
```

This puts you into class-map configuration mode.

Specifying what the class-map will match on

To do this, first attach the ACL to the class-map (unless you don't need an ACL). In class-map configuration mode, use the command:

```
awplus(config-cmap)#match access-group <number>
```

Next, use other match commands to further limit which traffic will match the class-map (unless the ACL's settings were enough). This means that you select the matching traffic by using a *combination* of the ACL's settings and the QoS match commands. The ACL and match commands are ANDed together to make the class-map's filtering rule. The available match commands are:

```
match cos
match ip-dscp
match ip-precedence
match eth-format protocol (or match protocol eth-format)
match tpid
match inner-cos
match inner-tpid
match inner-vlan
match mac-type
match tcp-flags
match vlan
```

Most of these options are self-evident, but the following sections give more information about the "inner" options, the TCP flags, and the eth-format and protocol options.

Except for TCP flags, each class-map can only match on one instance of each match type. If you enter multiple matches of the same type, the class-map uses the last match you specify.

If you need more than one filtering rule on the port, create class-maps for each other filter.

Matching on "inner" keywords for nested VLANs

The **match tpid**, **match inner-tpid**, **match inner-vlan**, and **match inner-cos** commands all apply to nested VLAN configuration. In this situation, the packets arriving at the core-facing port can have two VLAN tags configured on them.

- The **match tpid** command matches on the first Tag Protocol Identifier field in the packet.
- The **match inner-tpid** command matches on the TPID in the second 802.1Q tag in the packet.
- The **match inner-vlan** command matches on the tunnelled VLAN ID in the second 802.1Q tag in the packet.
- The **match inner-cos** command matches on the 802.1P field in the second tag in the packet.

The following table shows where in the packet the inner and outer tags will be matched.

	Outer VLAN parameters (normal)	**Inner VLAN parameters**
Customer port	VLAN	1st tag
Core port	1st tag	2nd tag
Nested VLANs disabled	1st tag	2nd tag

Some important points to keep in mind while configuring the "inner" commands are:

- When packets arrive at a customer port of a nested VLAN, the command **match vlan** will match the VID of the nested VLAN that the port is a member of, which is just how this command normally operates.
- When packets arrive at a customer port of a nested VLAN, the "inner" commands will match the attributes of the first tag in the packets. This is because when the packet is forwarded from the core port, that first tag will have become the inner tag. So, from the point of view of the nested VLAN, the tag that is on the packet when it arrives into the customer port is the inner tag.
- When nested VLANs are disabled, and "inner" commands have been configured in class-maps, these parameters will be applied as though all packets arriving at the switch were double tagged. In other words, there will be no attempt to make a distinction between "customer" and "core" ports. So, if the packets arriving at the switch are not double tagged, then the "inner" commands will just match on whatever data happens to be in the packets at the position where an inner tag would have been.

  Therefore, when you disable nested VLANs, you should also remove the match commands.
- When nested VLANs are being used, the commands **match tpid** and **match cos** cannot be used in class-maps applied to customer ports.
- If you attach the class-map to a number of ports, they will all be treated like core ports if at least one of the ports is a core port.

Matching on TCP flag

Unlike the other match commands, you can match on multiple TCP flags. The switch combines the specified flags by ANDing them together. To specify the multiple flags, either make multiple **match tcp-flags** commands or specify the flags in one command as a space-separated list. For example, the following series of commands will match on a packet that has all of ACK, SYN and FIN set:

```
awplus(config)#class-map tcp-flags
awplus(config-cmap)#match tcp-flags ack
awplus(config-cmap)#match tcp-flags syn
awplus(config-cmap)#match tcp-flags fin
```

So will the following single match command:

```
awplus(config)#class-map tcp-flags
awplus(config-cmap)#match tcp-flags ack syn fin
```

Note that QoS only checks that the specified flags are set, not that the other flags are not set. For example, the following commands will match on a packet that has both SYN and ACK set, as well as a packet that has SYN but not ACK set:

```
awplus(config)#class-map tcp-flags
awplus(config-cmap)#match tcp-flags syn
```

To drop packets with SYN only, but not with ACK and SYN, you could use the following two class-maps. Note that access-list 3000 is used to get a deny action. This example is explained fully in "Blocking TCP sessions in one direction" on page 17.

```
awplus(config)#access-list 3000 deny tcp any any
awplus(config)#class-map ack-syn-flags
awplus(config-cmap)#match tcp-flags ack syn
awplus(config-cmap)#class-map syn-flags
awplus(config-cmap)#match tcp-flags syn
awplus(config-cmap)#match access-group 3000
awplus(config-cmap)#policy-map flags
awplus(config-pmap)#class ack-syn-flags
awplus(config-pmap-c)#class syn-flags
```

Matching on eth-format and protocol

Ethernet format and protocol are specified together, as a pair. You can either specify the command as:

```
match eth-format <keyword> protocol <keyword-or-number>
```

or

```
match protocol <keyword-or-number> eth-format <keyword>
```

The switch allows you to match on any of the Ethernet formats, as the following output shows:

```
awplus(config-cmap)#match eth-format ?
  802dot2-tagged       802.2 Tagged Packets
  802dot2-untagged     802.2 Untagged Packets
  ethii-tagged         EthII Tagged Packets
  ethii-untagged       EthII Untagged Packets
  netwareraw-tagged    Netware Raw Tagged Packets
  netwareraw-untagged  Netware Raw Untagged Packets
  snap-tagged          SNAP Tagged Packets
  snap-untagged        SNAP Untagged Packets
```

Protocol options are also extremely flexible. You can identify common protocols by their name, or you can identify any protocol by using its hexadecimal protocol number.

Applying the class-maps to a policy-map

To create a policy-map, enter global configuration mode and use the command:

```
awplus(config)#policy-map <name>
```

Then add the class-maps to the policy-map. Make sure you add them in the order in which you want the switch to check them—see "The logic of the operation of the hardware filters" on page 13. For each class-map, use the command:

```
awplus(config-pmap)#class <name>
```

Applying the policy-map to ports

To apply the policy-map to ports, enter interface mode for the ports you want to apply it to. Use the commands:

```
awplus(config)#interface port1.0.11
awplus(config-if)#service-policy input <policy-name>
```

The logic of the operation of the hardware filters

The operation of the filters follows the standard ACL logic: if a packet matches an ACL on the port, the comparison process stops and the action attached to the ACL is performed. The switch checks ACLs **in the order in which you attach them to the port**.

For example, to reject all multicast traffic except 236.5.8.213, make one ACL to permit that address and another ACL to deny all multicast traffic. Then attach the permit ACL to the port before attaching the deny ACL.

If a packet fails to match any of the port's ACLs, then the switch moves to the next stage of comparison. The next stage is matching against QoS class-maps, if they exist. If the packet matches a QoS class-map, it will be processed appropriately. If it does not match a class-map, it will be processed as normal. Therefore, ACLs do **not** end in an implicit deny action to drop non-matching traffic. But they also do not end in an implicit permit action that would bypass other processing and forward non-matching traffic. The switch simply continues processing non-matching traffic as normal.

Note: ACLs will match on packets that are destined for the switch itself (packets that would be passed up to the switch's own CPU) in exactly the same way as they act on packets that were destined to be forwarded directly by the switching chip.

Combining interface ACLs and QoS class-maps

The switch compares the packet with every interface ACL before it compares the packet with any QoS class-maps. If the packet matches an interface ACL, the switch takes the action specified by that ACL and stops the comparison process. If a packet matches both an interface ACL and a QoS class-map, the packet only gets matched against the interface ACL. It bypasses the QoS process.

If the action on the interface ACL is **deny** or **send-to-cpu**, then this is not a problem, because the packet was never going to get into the QoS system anyway (given that it was being discarded). But, if the action on the interface ACL is **permit**, **copy-to-cpu**, or **copy-to-mirror**, and the packet would also be matched by a QoS class-map, then this is a problem. The packet will not be matched by the QoS class-map, so the switch will not apply any intended QoS-based filtering, policing, queue redirection, etc to the packet. Instead the switch will forward the packet as if it belongs to the default class-map.

For this reason, we only recommend combining interface ACLs and QoS class-map filtering if all your interface ACLs result in traffic being dropped. For traffic that you want forwarded with QoS control, use QoS class-maps for both the filtering and the QoS actions. Of course, you can also use QoS class-maps to drop traffic.

Examples

Blocking all multicast traffic

This example uses an interface ACL with an action of deny.

Consider a situation where multiple clients are attached to the switch, with each client attached to a different port. Each client has a specific service, which includes a set of allowed traffic types.

The client on port 1.0.10 is using a service that does not allow any multicast packets to be sent. To configure this:

1. Create an ACL to match and deny all packets with a multicast destination address. To do this, enter global configuration mode and use the command:

```
awplus(config)#access-list 3100 deny ip any 224.0.0.0/4
```

2. Attach the ACL to port 1.0.10. To do this, use the commands:

```
awplus(config)#interface port1.0.10
awplus(config-if)#ip access-group 3100
```

3. Verify the configuration.

   To see the ACL ID number and keywords, return to privileged exec mode and enter the command:

```
awplus#show access-list
```

   To see the ACLs that are attached to port 1.0.10, enter the command:

```
awplus#show interface port1.0.10 access-group
```

Blocking all multicast traffic except one address

This example uses two interface ACLs, one with an action of permit and one with an action of deny.

Use this type of configuration when you want to discard a wide range of traffic but want to forward a subset of traffic within that range.

Consider a situation where you want to prevent the forwarding of multicast traffic in general, but wish to support an application that needs to send packets to one particular multicast address (236.5.8.213 in this example). To configure this:

1. Create an ACL to match and permit packets with the multicast destination address 236.5.8.213. To do this, enter global configuration mode and use the command:

```
awplus(config)#access-list 3050 permit ip any 236.5.8.213/32
```

2. Create an ACL to match and deny all packets with a multicast destination address. To do this, use the command:

```
awplus(config)#access-list 3100 deny ip any 224.0.0.0/4
```

3. Attach the ACLs to the port (for example, 1.0.10). You must first attach the permit ACL, then the deny ACL. To do this, use the commands:

```
awplus(config)#interface port1.0.10
awplus(config-if)#ip access-group 3050
awplus(config-if)#ip access-group 3100
```

Mirroring HTTP and SMTP traffic

This example uses two interface ACLs with actions of copy-to-mirror.

Use this type of configuration when you want to mirror a subset of the incoming traffic on a port, instead of mirroring all incoming traffic.

Consider a situation where you want to capture the HTTP (TCP port 80) and SMTP (TCP port 25) traffic coming to users who are connected to ports 1.0.1-1.0.2. To configure this:

1. Set port 1.0.20 as the mirror port. To do this, enter global configuration mode and use the commands:

```
awplus(config)#interface port1.0.20
awplus(config-if)#mirror interface none direction both
```

2. Create ACLs to match HTTP and SMTP traffic. To do this, return to global configuration mode and use the commands:

```
awplus(config)#access-list 3100 copy-to-mirror tcp any any eq 25
awplus(config)#access-list 3200 copy-to-mirror tcp any any eq 80
```

3. Attach the ACLs to ports 1.0.1-1.0.2. To do this, use the commands:

```
awplus(config)#interface port1.0.1-1.0.2
awplus(config-if)#ip access-group 3100
awplus(config-if)#ip access-group 3200
```

Mirroring ARP packets

This example uses a QoS class-map.

Use this type of configuration when you want to mirror a subset of the incoming traffic on a port, and you need to use QoS match commands to select the mirrored traffic.

Consider a situation where you want to capture ARP packets that arrive at port 1.0.10. To configure this:

1. Set port 1.0.20 as the mirror port. To do this, enter global configuration mode and use the commands:

```
awplus(config)#interface port1.0.20
awplus(config-if)#mirror interface none direction both
```

2. Create an ACL with an action of copy-to-mirror. This ACL will only be used to set the action taken on the ARP traffic, not to select the traffic, so it needs to match all IP traffic. To do this, return to global configuration mode and use the commands:

```
awplus(config)#access-list 3400 copy-to-mirror ip any any
```

3. Create a class-map that matches on ARP traffic and uses the ACL. To do this, use the commands:

```
awplus(config)#class-map mirror-arp
awplus(config-cmap)#match protocol arp eth-format ethii-untagged
awplus(config-cmap)#match access-group 3400
```

4. Create a policy-map and add the class-map to it. To do this, use the commands:

```
awplus(config-cmap)#policy-map mirror-arp
awplus(config-pmap)#class mirror-arp
```

5. Apply the policy-map to port 1.0.10. To do this, use the commands:

```
awplus(config-pmap-c)#interface port1.0.10
awplus(config-if)#service-policy input mirror-arp
```

Blocking TCP sessions in one direction

This example uses two QoS class-maps.

Administrators often want to block the establishment of TCP sessions in one direction, but allow TCP sessions to be established in the opposite direction. To do this, it is necessary to block the very first packet of an outgoing TCP session from being forwarded, but to allow any packets that reply to the initiation of an incoming TCP session to be forwarded.

The very first packet of a TCP session has the SYN flag set, and no other flags. The reply to that packet has the SYN and ACK flags set, and no other flags. So, to block TCP sessions from being established in one direction, but not the other direction, we must block packets that have **only** the SYN flag set, but allow packets that have both the SYN and ACK flags set.

To configure this on port 1.0.10:

1. Create an ACL with an action of deny. This ACL will only be used to set the action taken on packets with only the SYN flag set, not to select the traffic, so it needs to match all IP traffic. To do this, enter global configuration mode and use the command:

   ```
   awplus(config)#access-list 3000 deny tcp any any
   ```

2. Create a class-map that matches on packets that have both the SYN and ACK flags set. To do this, use the commands:

   ```
   awplus(config)#class-map ack-syn-flags
   awplus(config-cmap)#match tcp-flags ack syn
   ```

   You want to permit this traffic, so you do not need to make an ACL to specify an action.

3. Create a second class-map that matches on packets that have only the SYN flag set. Use the ACL to give this class-map an action of drop. To do this, use the commands:

   ```
   awplus(config-cmap)#class-map syn-flags
   awplus(config-cmap)#match tcp-flags syn
   awplus(config-cmap)#match access-group 3000
   ```

4. Create a policy-map and add both class-maps to it. Add the class-map that matches both flags **first**, followed by the class-map that drops packets with only the SYN flag. To do this, use the commands:

   ```
   awplus(config-cmap)#policy-map flags
   awplus(config-pmap)#class ack-syn-flags
   awplus(config-pmap-c)#class syn-flags
   ```

5. Apply the policy-map to port 1.0.10. To do this, use the commands:

   ```
   awplus(config-pmap-c)#interface port1.0.10
   awplus(config-if)#service-policy input flags
   ```

How many filters can you create?

The total number of filters that can be created is not an exact number, but depends on which fields the various filters are matching on. So, to understand how to work out whether the set of filters you are creating might run out of space, it is necessary to understand the way in which the filters operate in the switch hardware.

There are two items within the switch hardware which set limits on the number of filters that can be created: the filter rules table and the profile (mask).

Filters share the same filter rules table and mask whether they are made by applying ACLs directly to ports or are made through QoS class-maps.

1. The filter rules table

One item that sets a limit on the number of filters is the table that contains the list of filter rules. This has a strict limit of 1024 entries. An entry gets made when:

- You apply an ACL to a port (with the **ip access-group** or **mac access-group** command)
- You apply a QoS class-map to a port by applying its policy-map to a port (with the **service-policy input** command). For each class-map, its ACL and any **match** commands are ANDed together to make a single filter entry.

Therefore, every ACL or class-map uses up one table entry for every port that it is applied to. Interface ACL rules come before QoS class-map rules. Conceptually, the table looks like:

port1.0.1	Interface ACL rule Interface ACL rule ... QoS class-map rule QoS class-map rule ...
port1.0.2	Interface ACL rule Interface ACL rule ... QoS class-map rule QoS class-map rule ...
...	...

If you specify a TCP or UDP port range, this may use multiple filter entries. The switch converts the range to a series of single TCP/UDP port numbers plus masks. It uses as few entries as possible to cover the range.

Also, the protocols that use filters (CPU protection and EPSR—see page 21) create one entry per port.

2. The profile (mask)

The other item is called the profile. Conceptually, this is a 16-byte mask that decides which set of bytes should be extracted from a packet as it enters the filtering process, to be compared against all the interface ACLs and the QoS class-maps. All filters share a single mask.

In effect, the mask is the sum of all the individual bytes required for each individual ACL or QoS match command. The number of bytes required by each ACL or match command depends on what fields it maps on. For example:

source MAC address—6 bytes

destination MAC address—6 bytes

Protocol type—2 bytes

Ethernet format—2 bytes

VLAN ID—2 bytes

IP protocol type (TCP, UDP, etc)—1 byte

source IP address—4 bytes

destination IP address—4 bytes

TCP port number—2 bytes

UDP port number—2 bytes

DSCP—1 byte

For example, if you make an ACL that matches on destination IP address and source TCP port, this adds 7 bytes to the mask:
1 byte for the IP protocol field (to indicate TCP)
4 bytes for the destination IP address
2 bytes for the source TCP port number.

If you next make an ACL that matches on source MAC address, this adds 6 more bytes to the mask.

If you next make a QoS class-map that matches on destination IP address (4 bytes) and DSCP (1 byte), this adds 1 more byte to the mask, for the DSCP. It does not add 4 more bytes for the destination IP address because the switch already matches on that field.

If you next make an ACL that matches on source IP address and source TCP port, then that does not change the mask, because the switch already matches on those fields.

If you next make an ACL that matches on source UDP port, this also does not add any length to the mask, because it shares the same 2 bytes as the source TCP port. However, if you next make an ACL that matches on *destination* TCP or UDP port, that uses another 2 bytes.

Are there enough bytes for your set of filters?

Of course, the mask cannot increase without limit—it has a maximum size of 16 bytes.

When it reaches the 16-byte limit, no more ACLs or QoS match commands can be created which would cause the mask to increase in size. The switch can still accept ACLs or QoS match commands that use fields that have already been included in the mask.

There is no particular number of ACLs or QoS match commands that will cause the mask to reach its 16-byte limit—it could happen after a few ACLs, or you might be able to create hundreds of ACLs and QoS match commands without the mask reaching its limit.

So to determine whether you will have enough filter length, look at the fields you want to filter, determine the number of bytes for each field, and sum up **the total number of bytes.** If that number is less than 16, there is enough filter length. Don't forget to count TCP and UDP source port as a single field, and likewise to count TCP and UDP destination port as a single field.

Okay length

For example, this set of ACLs would work:

source MAC address
source UDP port
destination IP address + destination TCP port

The total number of bytes for the switch to check in a packet would be:

source MAC address + IP protocol type + source TCP/UDP port +
destination IP address + destination TCP/UDP port =
6 + 1 + 2 + 4 + 2 = 15 bytes

Too long

But this set of ACLs would not work:

source MAC address
destination MAC address
destination IP address + destination TCP port

The total number of bytes for the switch to check in a packet would be:

source MAC address + destination MAC address + IP protocol type +
destination IP address + destination TCP/UDP port =
6 + 6 + 1 + 4 + 2 = 19 bytes

Some protocols also use filters, so use some of the length

The following protocols use filters, and therefore use up some of the available profile length and filter entries:

CPU protection

CPU protection is enabled by default. It controls the rate at which packets reach the CPU, and uses filters to ensure that ARP and unregistered multicast packets get prioritised appropriately.

It matches on:
Ethertype—2 bytes to check for ARP, and
VLAN tagging—2 bytes to check for tagged ARPs, and
destination MAC address—6 bytes to check for unregistered multicasts (01-00-5E-00-00-xx),
or
destination IP address—4 bytes to check for unregistered multicasts (224.0.0.x).

CPU protection automatically changes from using the destination MAC address to the destination IP address if you configure a filter that uses destination IP address (as long as no other filter already uses destination MAC address). This minimises the impact CPU protection has on the number of filters available. However, it still uses 8-10 bytes of width.

If you are sure your network will not have an excessive rate of broadcast and multicast traffic, you can turn off CPU protection by using the command **no platform cpuprotection**.

EPSR

EPSR matches on VLAN ID, which uses 2 bytes. EPSR is disabled by default.

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